Habitat selection of the long-legged myotis (*Myotis volans)* in a managed landscape on the east-slopes of the Cascade range.

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This project can be cited as: Taylor, J.A. 1999. Habitat selection of the long-legged myotis (*Myotis volans)* in a managed landscape on the east-slopes of the Cascade range. M.Sc. Thesis. Michigan State University, East Lansing, MI.

<keywords>
Myotis volans, habitat use, managed forests, Cascade range, radio-telemetry, retention, fragmentation

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ABSTRACT

Habitat fragmentation is often considered one of the biggest threats to bats in the Pacific Northwest. Yet, few studies have focused on how bats use habitat in heavily fragmented areas. The Northwest Forest Plan was created due to concerns about how the loss of late-successional forests negatively affects wildlife. This study focused on how the long-legged myotis (*Myotis volans*) utilizes various habitat types in the managed forests on the east slopes of the Cascade Range, including whether they utilize retention such as live trees or snags that were left in harvest areas. During this study, male *M. volans* were radio-tracked to their day-roost locations, which were primarily located in grand fir snags. Actual roost snags were then compared to random snags to determine what features are driving roost-site selection. The results from this study found that *M. volans* prefer late-successional forests over younger forest types. *M. volans* avoid harvest units, even when potential roost structures were available, yet bats did use retention that provided large structures, such as aggregate retention and shelterwoods. There was also a high dichotomy in the type of roost-sites that were selected by bats between the two study sites. This dichotomy appears to be based primarily on the height of the canopy , which likely affects the potential roost-site microclimate.

Click to see an image of Myotis volans with radio-transmitter

INTRODUCTION

In 1994, the Forest Ecosystem Management Assessment Team (FEMAT) developed the *Northwest Forest Plan* in an attempt to manage forests for wildlife and watershed integrity while still meeting the continued mandate for timber harvesting (FEMAT 1993). As directed by the *Northwest Forest Plan*, the U.S. Forest Service has implemented a series of management prescriptions designed to provide more connectivity to the landscape. These management prescriptions include leaving large structures in harvest areas such as live trees, standing dead trees (snags), and downed woody debris. Collectively these structures are called retention. These management prescriptions are designed to partially mitigate the negative effects timber harvesting has on wildlife. However, research is required to determine whether these management prescriptions actually benefit the wildlife species for which they were intended.

One group of species for which management prescriptions have been intended is bats. In recent years, bat conservation has become a major issue for forest managers because of suspected population declines and the lack of basic knowledge about bat ecology. Habitat fragmentation is often considered to be one of the biggest threats to bat populations. However, few studies have studied bat ecology in heavily fragmented areas (Campbell et al. 1996, Fenton 1997). In recent years, the conservation of bats has attracted the interest of timber companies and agricultural interests because of bats' high levels of insect consumption (Whitaker et al. 1977, Kunz 1982, Reis 1982, Whitaker 1993). In addition, many timber companies developing Habitat Conservation Plans (HCPs) with the U.S. Fish and Wildlife Service are now being required to include bats in their management plans (Hansen 1995). Landscape ecologists are also interested in bats because they are considered well suited as indicators of general environmental conditions because of their small size, mobility, and longevity (Fenton 1997).

The long-legged myotis (*Myotis volans*) is the largest of the seven species of *Myotis* bats that occupy the forests of the Pacific Northwest (Nagorsen and Brigham 1993). This species occupies montane forests across much of the western United States (Nagorsen and Brigham 1993). *M. volans* was listed by the U.S. Fish and Wildlife as a category two species and was identified by FEMAT as being associated with old growth forests, a species of concern due to reduced availability of old-growth habitat, and in need of further study because little information was available on this species (USDI 1994, FEMAT 1993).

It is now well known that many bat species in the western United States use snags in forests for day-roosting (Brigham 1991, Campbell et al. 1993, Betts 1996, Vanhof and Barclay 1996, Kalcounis and Brigham 1998, etc.). This is true of the long-legged myotis as well (Rabe et al. 1998, Ormsbee 1997, Frazier 1997). However, there is little information on how bats, including *M. volans*, select habitat for roosting, especially as compared to what is available in a landscape. Currently, only two studies have been published about the ecology of *M. volans* in the Pacific Northwest, and both were conducted primarily on females (Ormsbee 1997, Frazier 1997). Information on male roosting behavior is apparently lacking in the literature. This is a relevant because it is known that there are differences in roost structure selection and habitat use between males and females in many vespertilionid bat species due to differences in social behavior (Kunz 1982). In addition, all previous studies on *M. volans* have focused on describing roosting habitat without adequately addressing how this species roost habitat selection compares to availability.

Previous studies on *M. volans* have compared habitat use to availability across an entire watershed (Frazier 1997, Ormsbee 1997). However, there is no ecological reason for selecting that scale of analysis because these units are based not on bat behavior but, rather, on hydrology. Watersheds can vary greatly in size, but in the western United States, these areas can be quite large, often exceeding 50,000 ha. An area as large as a watershed is likely to be well beyond the normal home range of any individual bat. In order to scale down the area being used for analysis, it is necessary to define the area that is available to an individual bat on any given night. One factor that may help define the area available to a bat is their ecological tie to water. Several studies have shown that bats are ecologically tied to water sources and that limited water sources can limit the movements of individual bats (Tidemann and Flavel 1987, McNab 1982, Christy 1993, Marcot 1996, Ormsbee 1997). If a limited water source keeps individual bats in the same area night after night, then the distance that bats travel from that water source to their roost-sites can be used to determine what the available habitat is for selection. Since the study area of this project has limited and widely spaced water sources, it presents an opportunity to determine the area available to a bat for habitat selection. The goal of this study was to learn about the ecology of *M. volans* in a managed landscape at three spatial scales. These spatial scales include:

- Fine scale: The actual roost structures being used at the two study sites.
- Habitat scale: Habitat use compared to availability within each site.
- Landscape scale: Does roost structure selection and habitat use shift across a landscape as habitat structure changes?

Study Area

The study area for this project was located on the east slopes of the Cascade Range near the town of Trout Lake, Washington (Figure 1). The elevation of the study area ranges between 640 m and 1064 m. This study area is typical of forests on the east slopes of the Cascades, experiencing hot, dry summers. The average rainfall during July and August is less than 1.0 cm per month (Worldclimate.Com 1996). Most water sources in this area are intermittent because of this annual summer drought. The dominant forest tree species are Douglas fir (*pseudotsuga menziesii*), grand fir (*Abies grandis*), and ponderosa pine (*Pinus ponderosa*). Within the study area were two study sites separated by approximately 16 km. These sites are oriented west to east and are hereafter called the west site and east site. The west site is located primarily within the Gifford Pinchot National Forest (Figure 1). The east site is located primarily on the lands of a private timber company, Champion Pacific Timberlands, Inc. (CPTI) (Figure 1). Because of the strong rainshadow effect in this study area, yearly mean precipitation decreases from approximately 150 cm at the west site to 110 cm at the east site.

METHODS

At the west site, bats were captured with a mist-net at a lava tube entrance as they entered the cave at dusk from the surrounding forests to drink and forage. This lava tube is the only known available water source for approximately 1.5 km. At the east site, bats were captured with mist-nets at two locations, a cattle trough and at a small spring pond, that are separated by approximately 400 m. These sites are the only known water sources in a radius of approximately 2.6 km.

Radio-transmitters were glued to the backs of male *M. volans* using Skin-Bond® surgical adhesive (Smith and Nephew United, Largo, Florida). The transmitters used for this project were Holohil Systems (Carp, Ontario, Canada) 0.47 g or 0.51 g LB2 and Titley Electronics (Ballina, NSW, Australia) 0.50-g LT1 transmitters. Image 1 illustrates the size of the transmitter on the back of a bat.

At each roost-site, the following roost-site attributes were measured; roost-tree species, height, DBH, decay class, and canopy cover. In addition, a 15-meter radius plot (0.071 ha) was set up around each roost. Within this plot, average canopy height and average stem DBH were measured. Measurements for trees within each plot were restricted to canopy trees. Canopy trees were defined to be those that were at least 50% as tall as the overlying canopy. This restriction prevented seedlings/saplings and stumps from being included in the analysis.

For every roost that was used, a random roost-site was also located to compare roost structure use to availability. These random roosts were located at a random distance and direction from the actual roost using a random number table. Because over 95% of the actual roosts were snags, random sites were limited to snags to simplify random roost selection and location. The distance between a random snag and an actual snag had to be greater than 30 m to prevent an overlap of the plots. Random snags were required to be a minimum of 6.4 m tall and greater than 25 cm DBH, as this was the size of the smallest actual roost used by a bat in this study. This restriction was used to assure that dead saplings and stumps were not selected, as these features were assumed to be unusable by bats. This also assured that comparisons were conservative estimates of use to availability. Once a random snag was selected, all of the same snag and plot measurements were taken as for an actual roost site.

For analysis of roost attributes, a series of paired t-tests with Bonferroni adjustments were used to compare actual roosts to random roosts at each site, and to compare the actual roost results between the west site and east site. Statistical analysis was conducted using SYSTAT 8.0 (SPSS Inc. 1998). Many bats used multiple roosts during this study. To avoid problems of non-independence, the characteristics of all the roosts used by each individual bat were averaged and these mean values were used in the statistical analysis. Analysis of use versus availability for snag species, snag class, and habitat selection was conducted using a computer program called "Resource Selection for Windows", created by Fred Leban, University of Idaho. This program used the statistical tests described by Johnson (1980) as the primary procedure for analysis. Snag class categories were based on the criteria of Cline et al. (1980), which included five snag classes that ranged from young , intact Class 1 snags to extensively decayed Class 5 snags. To avoid non-independence issues in the use versus availability analysis, the proportion of use by an individual bat was used. For example, if a particular bat used one a Class 1 snag and one Class 2 snag during the study, these roosts were weighted 0.5 and 0.5 respectively.

Available Habitat Areas

The Available Habitat Area (AHA) is defined as the amount of area that was potentially available for any individual bat to use in an evening. One AHA was defined for each study site (see Figure 1). The AHA was created by drawing a radius from the water source to the furthest roost used by any bat captured at that water source. The west site AHA had a radius of 1.8 km. The east site AHA consisted of two overlapping circles of radii 1.16 km and 1.56 km, due to the two water sources within the study site. The vast majority of the bats stayed within 1 km of the water source. The bats likely stayed close to these water sources because water is so limited due to the annual summer drought. In addition, the water sources were also areas of locally high insect abundance. The theory behind the Available Habitat Area is that once a bat visits the water source at dusk, it can then leave in any direction afterwards to forage and find the next day's roost. Thus, a circle with a radius drawn from the water source to the farthest roost-site is in essence an estimate of the habitat available for selection by the bat once it leaves the water source. An Available Habitat Area is not a home range, because the actual area a bat travels through in an evening is not known. Nonetheless, this method is less arbitrary and contains a much smaller area of analysis than the "entire watershed" approach used by Ormsbee (1997) and Frazier (1997). Nighttime telemetry indicated that many bats visited the same water source night after night to drink and forage, thus indicating that the area used by these bats is relatively small.

Stand Type Classification

Within each AHA, habitat polygons, which are sections of forest containing the same habitat structure, were mapped based on U.S.F.S. and C.P.T.I. aerial photos in a G.I.S. Field reconnaissance confirmed the location and vegetation class of the polygons. All habitat polygons were placed into one of eight vegetation stand types. These stand classifications were based on the work of Oliver and Larson (1990) and McGrath (1997). However, they were modified to meet the characteristics of the vegetation and management techniques unique to this study area and were based on current available stand structure. In general, classifications were based on the successional stage; however, two harvest techniques are also included. In the results and discussion sections, the term harvest unit will be used referring to the two earliest successional stages, stem initiation and stem exclusion, as well as shelterwoods and aggregate retention patches.

The species composition in this study area is affected not only by natural successional processes, but also by timber practices and over 100 years of fire suppression. Douglas fir (*Pseudotsuga menzeisii*) and grand fir (*Abies grandis*) are dominant canopy species in all but the pine/oak stand type. At the east site, ponderosa pine also becomes a dominant canopy tree. The pine/oak stand type, located at the eastern edge of the east site, is dominated by ponderosa pine (*Pinus ponderosa*) and Oregon white oak (*Quercus garryana*) with Douglas fir and grand fir becoming only a secondary component. To see an illustration of some of the retention types see Figure 2.

Stand initiation (SI): Early-successional stage, mostly planted with Douglas fir, grand fir or ponderosa pine, but often containing several other species for "stand diversity". SI is exclusively caused by clear-cutting, single-step regeneration within this study area, but can potentially be caused by any stand replacement event such as fire. Stands are generally younger than 30 years of age. The average tree DBH is less than 13 cm. The canopy is less than 5.0 m high.

Shelterwood (SH): This is a management technique is similar to the stand initiation stage, except that large overstory trees are left in moderate density, evenly distributed across the harvest unit. Shelterwoods tend to be dominated by Douglas fir, with a pine/fir understory. These overstory trees are exposed to wind, logging damage, and heat from slash treatment which can cumulatively result in high tree mortality, as well as, many live trees with broken tops and few branches.

Aggregate Retention (AR): This is a patch of live trees of the pre-harvest stand density that was left in a harvest unit. These aggregates are too small to function as interior forest, especially in terms of stand microclimate. The aggregate retention patches are generally less than 0.5 hectares in area.

Stem-exclusion (SE): An early successional stage directly following stand initiation. In this stage, high stem density results in total canopy closure and prevents any further stems from growing in the understory. Stands are generally 30-50 years of age. Average tree DBH is 13-38 cm. The canopy height is 5-15 m.

Stem re-initiation small (SRS): A middle-successional stage. When natural or commercial thinning begins to eliminate some of the overstory trees, the canopy opens up and gaps are created, allowing new undergrowth to grow. All understory trees are still seedlings. These stands are generally 50-80 years of age. The average dominant tree DBH is less than 38 cm. The canopy height is 15-30 m.

Stem re-initiation medium (SRM): A similar stage to stem re-initiation small, but more advanced. Gaps are present and most understory trees are seedlings to pole-sized. These stands are generally 70-100 years of age. The average dominant tree DBH is 38-53 cm DBH. The canopy height is 25-35 m.

Stem re-initiation large (SRL): A mature late-successional forest stand. Usually large gaps are present in the canopy and understory trees of all ages are present. These stands are generally greater than 100 years of age. The average dominant tree DBH is greater than 55 cm. The canopy height exceeds 35 m.

Middle to late successional pine/oak (PO): At the eastern edge of this study area the forest shifts from one dominated by Douglas fir/grand fir to one dominated by ponderosa pine and Oregon white oak. This pine/oak habitat does contain some fir component, but the structure of the stand is different than the fir dominated stands. The structure is most similar to SRM, but the canopy tends to be lower and more open (between 30-70%). As ponderosa pine grows taller than the Oregon white oak, there is high canopy height diversity.

RESULTS

Roost-sites were located for 35 individuals, of which 18 were located at the west site and 17 at the east site. A total of 31 west site roosts and 33 east site roosts were located. At the west site, long-legged myotis selected very tall Class 1 snags. Roost height and DBH were both significantly greater for actual roosts than random roosts (Table 1). At the east site, there was a very different pattern of selection. None of the roost-site attributes were significantly different between actual and random roosts (Table 2). The west site measurements were significantly greater than the east site for every attribute, except the number of snags per plot. At both the west site and east site, random snags were significantly shorter than the canopy height of the stand (Figure 4). This is to be expected, as dead trees are more likely to have their tops blown off by wind or damaged through decay. At the east site, actual roost snags were also significantly below the canopy. However, at the west site, actual roost snags were level with or above the canopy (Figure 4).

Snag Species Selection

Of the 64 roosts that were located, 61 were snags and three were live trees: two Douglas firs and one Oregon white oak. The characteristics that all three live tree roosts had in common with roost snags were cavities in the bark due to woodpeckers and natural decay. At the west site, roost-site selection strongly favored grand fir snags over Douglas fir (Figure 3). Over 77% of the snags that were used were grand firs, while only 6% were Douglas firs. A few other snag species were used in small numbers, but in every case they resembled grand fir in their state of decay and bark exfoliation. At the east site, grand fir snags were less abundant in relative terms than at the west site. Yet, bats used grand firs significantly more than would be predicted by availability. Douglas firs were used at about the same frequency as expected, while Ponderosa pine snags were used significantly less than predicted (Figure 3).

Snag Class Selection

At the west site, Class 1 snags were selected significantly greater than expected, while Class 2 snags showed no significant difference. Class 1 and 2 snags represented the youngest, most intact snags. Classes 3 and 4, the most decayed snags, were selected significantly less than expected. Class 5 snags were not found at this study site (Figure 5). At the east site, the pattern of decay class selection was the opposite of what was found at the west site. Classes 1 and 2 were used significantly less than expected, while Classes 3, 4, and 5 were selected more than expected (Figure 6). However, it should be noted that Classes 1 and 2 were used 45% of the time at the east site. Thus, there was not a strong avoidance of the younger snags at the east site.

Habitat Use Versus Availability:

At the west site, only one stand type was used significantly more than availability, that was the stem reinitiation large (SRL) or the late-successional forest type. Over 83% of the roosts were located in this stand type. While stem reinitiation medium (SRM) and stem reinitiation small (SRS) were used significantly less than availability, they were the only other forest types used at the west site (Figure 7).

At the east site, on the other hand, SRM was used significantly more than availability. As there was no SRL available at the east site, SRM was the most mature stand type available. The selection of the most mature stands is therefore, similar to the pattern of habitat selection at the west site. While it appeared as though bats at the west site avoided retention snags in harvest units entirely, there were bats at the east site that used snags in harvest units. In fact, at the east site, 28% of the snags that were used were located in harvest units. However, of the harvest unit stand types, only aggregate retention patches were used more often than expected. These aggregate retention patches resemble older stand types in structure. In addition, at the east site the pine/oak stand type, which is similar in structure to SRM, was also used significantly more than availability (Figure 8).

DISCUSSION

The long-legged myotis exhibited some very distinct patterns of roost-site selection and habitat use across the landscape. This species selected the most mature forest stands available. At the west site, *M. volans* selected the oldest available forest stands (SRL) almost exclusively, avoiding younger successional stages and harvest units. At the east site, the oldest forest stands were only moderately mature SRM stands, yet *M. volans* selected these oldest available stands (Figure 8). They also selected moderately mature stands of pine/oak, and aggregate retention patches that resembled the older stand types in structure, but not area (Figure 8).

Some might note that at the east site this species did not use SRM exclusively. In fact, bats were occasionally found using retention snags within harvest units. This may lead to the conclusion that this species will roost in harvest units provided there is some retention. It should be noted, however, that the three earliest successional stages (SI, SE, SRS) were used less than availability (Figure 8). Only when large structures were left in relatively high densities, such as the shelterwoods and aggregate retention patches, did bats not avoid harvest units (Figure 8). Since these aggregate retention patches resemble more mature stand types in structure, but not in area, this finding might have been expected, especially in areas where late-successional stands are lacking. The fact that bats were never found in harvest units at the west site supports this conclusion.

The results of this study suggest that late-successional forests, including possibly old-growth, are the highly preferred habitats for *M. volans*. However, when those late-sucessional stages are not available, this species appears flexible enough to use younger successional stages, provided the necessary roosting structures (snags) are available in a relatively high density. These conclusions are consistent with the results of Ormsbee (1997).

While *M. volans* may be flexible enough to use roosting structures in less than ideal habitats, the implications for the population dynamics of this species are unclear. The relative population densities of the two study sites were not measured in this study and in fact, no studies of population densities have ever been done for this species. It is also unclear whether the reproductive success of this species is affected by habitat quality.

Looking at finer scale roost-site selection, it appears that selection shifted between the west and east. At the west site, there was very strong selection for the largest snags available. The structures bats selected at this site were characterized as being Class 1 snags greater than 32 m tall, often at or above the top of the canopy (Figure 4). Ormsbee (1997) found that female *M. volans* also used snags that extended above the canopy. However, at the east site, bats selected snags that were significantly below the top of the canopy (Figure 4). East site bats selected all decay classes with some preference for the more decayed snag classes.

One possible explanation for this shift in snag size and decay class selection may be that snags located at the top of the canopy in closed-canopy stands may produce a microclimate similar to the smaller, more decayed snags found in open-canopy forest stands. Microclimate is an important factor for bats because of their unique physiology. Many bat species in North America go through torpor during the day, when they reduce their body temperature from 37° C down to near the ambient air temperature. This reduction in body temperature reduces their metabolism and allows them to conserve energy. However, when they emerge from torpor in the early evening, they must warm themselves back to their active temperature using their fat reserves. However, if a bat is roosting in a location that receives solar radiation in the late afternoon, this radiant energy will heat their bodies and would result in a reduced need to burn fat. Therefore, it may be advantageous for bats to select roosts that will receive sunlight in the late afternoon, such as the west side of a snag that extends above the canopy in a closed-canopy stand or possibly a shorter snag in a more open canopy forest. A valuable additional study would be a comparison of the microclimates of potential roosts (i.e. under the exfoliating bark) in snags that extend above the canopy in closed-canopy stands to snags that are below the canopy in open-canopy stands.

While the size and class of the roosting snags may have differed between west and east, snag species selection did not. Grand fir was used significantly more than availability at both study sites (Figure 3). In fact, it was the only species of snag used greater than expected. However, grand fir abundance decreased west to east from the Cascade crest. It is unclear whether a reduced abundance of grand fir has any effect on *M. volans* population size. At Ormsbee's study area (1997), grand fir was not available and *M. volans* selected primarily Douglas fir. However, when given equal abundance of Douglas fir and grand fir, such as at the present study area, this species strongly selected grand fir at both study sites. Rabe et al. (1999) found that *M. volans* used ponderosa pine exclusively at his study site in northern Arizona, but his site also lacked grand fir. When grand fir and ponderosa pine both exist in a landscape, such as at the east site, *M. volans* used ponderosa pine significantly less than expected (Figure 3).

MANAGEMENT IMPLICATIONS

Grand fir (*Abies grandis*) is the roost-tree species most preferred by the long-legged myotis (*Myotis volans*) on the east slopes of the Cascade Range. This preference is likely due to the particular way in which grand fir decays. Grand fir snags tend to have exfoliating bark that resembles shingles on a roof. As thin plates of bark peel away from the trunk, they provide accessible crevasses that bats can utilize for roosting. Douglas fir (*Psuedotusga menziesii*) and ponderosa pine (*Pinus ponderosa*), on the other hand, exfoliate by dropping large slabs of bark. When Douglas fir and ponderosa pine snags were observed being used by bats during the study, the pattern of bark exfoliation appeared more similar to grand fir than to most of the other Douglas fir and ponderosa pine snags in the landscape. It is difficult to quantify bark exfoliation for analysis, however, from a qualitative comparison; shingle-like exfoliating bark appears to be one of the characteristics that *Myotis volans* is selecting for. The selection of shingle-like exfoliation may be related to the microclimate that that type of exfoliation provides, as well as, other factors including protection against predators and the long-term stability of the roost-site. While most of the tree species present in the study site are capable of producing suitable roosts, it appears that grand fir, in general, tends to provide the type of roost-site *M. volans* prefer more often than the other snag species in this landscape.

Throughout the east slopes of the Cascade Range forest managers are becoming ever more concerned with the increasing abundance of grand fir. Grand fir is highly susceptible to fire. Historically, when there was an active fire regime, much of the east slope forests were dominated by fire-tolerant Douglas fir and ponderosa pine (USGS 1998). These forests were a complex mosaic of stands of varying ages and stand structures. In these Douglas fir/ponderosa pine dominated stands, grand fir was primarily a secondary component of the forests. Stands dominated by grand fir were infrequent and tended to be located in areas of locally high moisture and/or humidity, such as in drainages or north-facing slopes. However, over 100 years of fire suppression and the selective harvesting of mature ponderosa pines and Douglas firs, has allowed grand fir to become one of the dominant canopy trees throughout the east slopes of the Cascade Range. The west site of this study area is located in the grand fir zone, and within this zone grand fir is expected to be one of the dominate canopy trees under stable climax conditions (Topik 1989). Nonetheless, grand fir has increased in density and abundance above historic levels in this zone. The east site is located in the Douglas fir and ponderosa pine zones, yet regeneration of grand fir dominated stands is not uncommon following timber harvests. Grand fir commonly establishes itself in clumps of moderate to high stem density. When grand fir occurs in high densities, intra-specific competition for limited resources stresses the trees, increasing the chances of disease and mortality (USGS 1998, USFS unpubl. reports). Exacerbating the problem is the fact that grand fir stands are far more susceptible to spruce budworm outbreaks than Douglas fir or ponderosa pine (CPTI, USFS pers. comm.). A high mortality rate in high-density stands caused by disease and insect outbreaks increases the possibility for catastrophic stand replacement fires.

Because of its susceptibility to fire, disease, and insect outbreaks, forest managers do not consider grand fir an optimal tree species and many managers are considering replanting areas with less susceptible species, such as ponderosa pine (CPTI, USFS, pers. comm.). Despite these forestry concerns, grand fir remains an integral component in the landscape and provides essential habitat for many species for wildlife. This study has shown that the long-legged myotis strongly prefers grand fir snags as roost structures. In addition, other bat species, small non-volant mammals, woodpeckers and many other bird species utilize grand fir extensively (Harris et. al 1982, USFS unpubl. data). As forest managers attempt to reestablish an active fire regime in the ecosystem and control spruce budworm outbreaks, managers should also attempt to maintain a grand fir component to the forests, especially within the grand fir zone.

The necessary grand fir component could be maintained for wildlife, while still limiting the susceptibility of the forest to fire and/or insect outbreaks, by thinning high-density grand fir stands. In newly harvested areas, grand fir seedlings could be spaced out evenly with other historically present species throughout a stand. If grand firs are spaced apart in a stand to limit intra-specific competition, the risks of stand-replacement events decrease substantially. Grand fir can still be planted in moderate densities in areas of locally high moisture such as drainages and near cave entrances, to mitigate the loss of grand fir density elsewhere.

Many forest managers on the east slopes of the Cascade Range have been focusing their efforts on providing dispersed retention snags within harvest units as a way to keep some continuity of habitat in the landscape for wildlife (FEMAT 1993). While this method may be successful for some wildlife species, it does not appear to be a solution for the long-legged myotis. This species shows a strong preference for late-successional forest stands (Figures 7 and 8). While *M. volans* appears willing to use aggregate retention patches that provide the structure of late-successional forests, these patches likely lack the microclimate regime of more continuous tracks of forest (Chen et al. 1995). Leaving aggregate retention patches and shelterwoods in clear-cuts may be able to mitigate the effects of timber harvests to some degree. However, when given the choice between late-successional stands and aggregate retention patches, *M. volans* avoided the aggregate retention patches. If given a limited amount of timber to retain from harvest, it may be most useful for the conservation of the long-legged myotis to keep the retained timber connected as relatively large tracts of late-successional forest, rather than spreading it out across the landscape as retention.

In recent years, forest managers have been creating snags out of live trees for use by wildlife. Several methods of snag creation are often used. Girdling kills the trees slowly, leaving the snags intact, while dynamiting destroys the top of the tree. When selecting a method designed to provide bat roosting structures in closed-canopy stands, it appears as though girdling may be preferable over dynamiting. Intact snags of the early decay classes were used almost exclusively at the west site and used nearly half of the time at the east site. These tall intact structures may provide a more suitable microclimate than the shorter snags that would result from the dynamiting method in closed canopy stands.

The long-legged myotis appears to be a somewhat adaptable species. It is not considered an abundant species on the east slopes of the Cascades, but it is not considered be particularly rare either. It occurs in a wide range of habitats throughout western North America. Even in relatively small areas, it can be found utilizing several different forest types, including closed-canopy grand fir stands and open-canopy pine/oak forests. However, despite this apparent flexibility, the species does appear to select roosts that are located in relatively continuous tracts of late-successional forest. Much still needs to be learned to assure the conservation of this species. The microclimate requirements for day roosts need to be better understood so that roosting behavior can be better predicted and incorporated into management plans. Nighttime foraging patterns need to be assessed, so that managers can determine whether forestry practices affect foraging success or energy use. Nonetheless, despite the many gaps in our understanding of bat ecology, current information indicates that with careful stewardship of our forest resources, the long-legged myotis should be able to persist in the managed landscape of the east slopes of the Cascade Range.

ACKNOWLEDGEMENTS

Funding and logistical support for this project was provided by the U.S.D.A. Forest Service and Champion Pacific Timberlands, Inc. Additional funding was provided by Bat Conservation International and the Washington Department of Fish and Wildlife. We are especially thankful to Jessica Eskow of Champion Pacific Timberlands Inc. and the staff of the Mt. Adams Ranger District, Gifford Pinchot National Forest for all of their time and effort. In addition, we sincerely appreciate the hard work and dedication of our field assistants Greta Turschak and Sam Latra. Thanks to Richard W. Hill, the advisor of Jeffrey Taylor, for all of his guidance, patience, and support, as well as, committee members Henry Campa and Donald O. Straney. In addition, thanks to the Department of Zoology and the Ecology, Evolution, and Behavioral Biology Program (EEBB) at Michigan State University for their support. Finally, thanks to the Washington Department of Natural Resources for allowing us facilitating access to public lands for this study.

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studyareamap.jpg
Study Area Map

Figure2.jpg
Retention Types

Table1.rtf
West Site Roost Attributes

Table2.rtf
East Site Roost Attributes

Figure3.jpg
Snag Species Selection

Figure4.jpg
Canopy Height Comparison

Figure5.jpg
West Site Snag Class Selection

Figure6.jpg
East Site Snag Class Selection

Figure7.jpg
West Site Habitat Selection

Figure8.jpg
East Site Habitat Selection

Image1.jpg
Myotis volans with transmitter